PATENT SPECIFICATION

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COMPLETE SPECIFICATION

NO DRAWINGS

Improvements in Copper-Nickel Alloys

We, LANGLEY ALLOYS LIMITED, a Body Corporate duly organised under the Laws of Great Britain, of Langley, Slough, in the County of Buckingham, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to copper-nickel alloys.

For many years cupro-nickels (copper-nickel alloys containing up to about 40% nickel) have been regarded as the most suitable types of alloy for handling certain corrosive liquids and, in particular, sea water, and they have been extensively used for items such as condenser tubes.

Considerable research has been carried out with a view to improving still further the properties and, in particular, the corrosion resistance of these alloys.

However, the cupro-nickels used to date are generally of comparatively low strength although possessing extreme good ductility.

The following is a typical example of the mechanical properties of a standard alloy composed of 70% copper, 30% nickel, after hot working and annealing:

0.5% Proof Stress	— 10 Tons/sq.in.
Tensile Strength	— 28 Tons/sq.in.
Elongation	— 45%
Izod Value	— 80 ft. lbs.

There is now a growing demand for materials of this type which have the ability to withstand much higher stresses in service and consequently must possess higher strengths and, in particular, appreciably high yield strength or proof stress values, although the ability to withstand shock loads must not be too greatly reduced and hence the required alloys must retain a high degree of ductility particularly as measured by the Izod Impact Value.

The addition of niobium to alloys of this group as the means of achieving higher tensile strengths is already being investigated and properties of the following order can now be achieved on alloys containing 70% copper, 30% nickel to which has been added 2% of niobium as a strengthening element. These properties were obtained on this alloy after hot working followed by precipitation hardening.

0.5% Proof Stress	— 25 Tons/sq.in.
Tensile Strength	— 46 Tons/sq.in.
Elongation	— 22%

The beneficial effects of aluminium as a strengthening agent in cupro-nickels has also been known for some considerable time and one of the highest strength alloys in this series, known as HIDURAX (Registered Trade Mark) SPECIAL — the typical composition of which is as follows:—

Nickel	14.90%
Aluminium	2.60%
Iron	1.00%
Manganese	0.15%
Copper	Remainder

possess the following mechanical properties in the *hot rolled* condition:—

0.1% Proof Stress	— 42.4 Tons/sq.in.
Tensile Strength	— 58.4 Tons/sq.in.
Elongation	— 13.5%
Izod Value	— 10 ft. lbs.

It will be noted that this alloy possesses a Proof Stress and Tensile Strength far higher than either of the alloys quoted above but the ductility as measured by elongation and Izod Impact value is appreciably lower.

HIDURAX SPECIAL is precipitation hardening, and because of this the ductility is reduced still further if the alloy is heated within the precipitation hardening range 400°C.-600°C. and consequently it is not considered suitable for services within this

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range of temperature particularly if subjected to shock loading. This embrittlement at elevated temperatures may also impair the weldability of the alloy.

In the past it has been considered that in order to achieve the best combination of properties in such copper-nickel-aluminium alloys, the ratio of nickel to aluminium should be in the region of 5:1.

It has now been found that increasing this ratio still further, results in an alloy possessing considerably higher ductility, as measured by elongation and Izod Impact Value although the proof stress and tensile strength are only slightly reduced if the nickel and aluminium contents are correctly selected, as shown by the following Example 1.

Composition

L.14	Nickel	16.1%
	Aluminium	1.71%
	Iron	1.47%
	Manganese	0.25%

Balance substantially all copper

Mechanical Properties when hot rolled in the temperature range 1000°C.-1050°C.

0.1% Proof Stress	— 35.2 Tons/sq.in.
Tensile Strength	— 47.2 Tons/sq.in.
Elongation	— 21%
Izod Value	— 30 ft. lbs.

As a further improvement in the mechanical properties of these copper alloys it has now been established that if a substantial percentage of manganese namely more than 3% but less than half the nickel content is present in these alloys of high nickel to aluminium ratio, a further substantial increase in the Izod Impact value is achieved, as shown in the following Example II.

Composition

L.17	Nickel	17.3%
	Aluminium	1.59%
	Iron	1.14%
	Manganese	4.87%

Balance substantially all copper.

Mechanical Properties in the hot rolled condition.

0.1% Proof Stress	— 34.4 Tons/sq.in.
Tensile Strength	— 46.4 Tons/sq.in.
Elongation	— 29%
Izod Value	— 60 ft. lbs.

Such alloys may be subjected to precipitation hardening treatment in order to increase the proof stress and tensile strength although some reduction in Izod Impact Value occurs, the final result is still very much higher than could be achieved with the alloy hereinbefore referred to as HIDURAX SPECIAL.

The following is illustrative:

EXAMPLE III

Composition

L.20	Nickel	18.2%
	Aluminium	1.86%
	Iron	1.32%
	Manganese	4.77%

Balance substantially all copper.

Mechanical Properties	*Hot rolled*	*Heat treated 4 hrs. @ 550°C.*
0.1% Proof Stress	29.6	36.0 Tons/sq.in.
Tensile Strength	45.6	54.8 Tons/sq.in.
Elongation	30%	22%
Izod Value	70	37 ft. lbs.

After hot working such alloys may be softened by solution treatment in the temperature range 750°C.-1050°C. to give the following mechanical properties in the case of an alloy of the composition given in Example II.

0.1% Proof Stress	— 7.92 Tons/sq.in.
Tensile Strength	— 27.08 Tons/sq.in.
Elongation	— 60%

In this condition the alloys may be precipitation hardened at temperatures within the range 350°C.-650°C. and suitably for 4 hours at 600°C. at shown by the following:

0.1% Proof Stress	— 28.8 Tons/sq.in.
Tensile Strength	— 48.0 Tons/sq.in.
Elongation	— 28.0%
Reduction in Area	— 42.5%

In the solution treated condition they are ideally suited to cold drawing or cold rolling operations for the production of strip, wire, tube, rod or sheet.

Following this treatment they may be subjected to a precipitation hardening when the following extremely good combination of strength and ductility, as measured by Izod Impact Value, can be achieved.

	Cold rolled and heat-treated 4 hrs. @ 450°C.
0.1% Proof Stress	— 48.0 Tons/sq.in.
Tensile Strength	— 56.3 Tons/sq.in.
Elongation	— 16%
Izod Value	— 46 ft. lbs.

It has previously been stated that the alloy referred to as HIDURAX SPECIAL exhibits a serious loss of ductility at temperatures in the region of 400°C.

However, Alloy L.20 (see Example III) when tested in tension at 400°C. possessed the following properties:

Tensile Strength	— 36.8 Tons/sq.in.
Elongation	— 24%

whereas an alloy of the HIDURAX SPECIAL type composition, when tested in tension on 400°C. possessed the following properties:

Tensile Strength	— 41.75 Tons/sq.in.
Elongation	— 1.0%

The first production heat of an alloy according to the invention having the composition:

Nickel	18.3%
Aluminium	1.66%
Manganese	5.0%
Iron	1.47%

Balance substantially all copper.

was cast as 6¾" diameter ingots which were hot rolled from 1020°C. to 2⅞" diameter bar.

The properties were:

0.1% Proof Stress — 33.5 Tons/sq.in.
Tensile Strength — 51.5 Tons/sq.in.
Elongation — 32.5%
Izod Value — 61 ft. lbs.

It is to be understood that the expression "Balance substantially all copper" is intended to indicate that the balance is all copper except for impurities commonly found in copper base alloys.

Additional Elements

0.2% up to 3% niobium and/or silicon may be introduced with beneficial effect.

The properties of alloys containing these elements are shown in Table 1, from which it will be seen that the effect of niobium is particularly beneficial in developing high strength combined with high ductility in the hot rolled condition. The proof stress and tensile strength of this alloy in the hot rolled condition are in fact very similar to those obtained on the alloy HIDURAX SPECIAL but the Izod impact value is considerably higher.

The presence of silicon results in an alloy possessing extremely high tensile strength combined with good ductility and improved resistance to wear or abrasion.

Alloys according to the invention may also be produced in the form of sand castings in which condition they possess an excellent combination of properties as shown by the following Example.

An alloy of the composition:

Nickel	17.3
Aluminium	1.96
Manganese	5.15
Iron	1.32

Balance substantially all copper when cast into a sand mould possesses the following mechanical properties:

0.1% Proof Stress — 29.0 Tons/sq.in.
Tensile Strength — 43.0 Tons/sq.in.
Elongation — 13%
Izod Impact Value — 28 ft. lbs.

The alloys covered by this invention possess very low magnetic permeabilities as shown by the following Examples:

EXAMPLE IV

An alloy of the following composition:

Nickel	16.9%
Aluminium	1.35%
Manganese	5.30%
Iron	0.88%

Balance substantially all copper when produced in the form of hot rolled bar pos-

TABLE 1

Analysis												
Melt No.	*Copper %*	*Nickel %*	*Aluminium %*	*Manganese %*	*Iron %*	*Additional Element %*	*Condition*	*0.1% Proof Stress T/sq.in.*	*Tensile Strength T/sq.in.*	*Elong. %*	*Redn in Area %*	*Izod ft.lbs.*
E24	Balance	17.0	1.76	4.7	0.88	Nb 0.35	Hot rolled	41.6	56.0	22.0	47.5	52
	"	17.0	1.76	4.7	0.88	0.35	Hot rolled+4 hrs. @ 550°C.	44.8	61.6	18.0	32.5	26
E27	"	22.0	1.92	5.30	0.28	Nb 0.33	Hot rolled	43.2	59.6	19.0	42.5	28
	"	22.0	1.92	5.30	0.28	0.33	Hot rolled+4 hrs. @ 550°C.	48.0	64.0	15.0	27.5	13
E23	"	17.9	1.92	4.70	0.95	Si 0.65	Hot rolled	50.4	61.0	19.0	30.0	17
	"	17.9	1.92	4.70	0.95	0.65	Hot rolled+4 hrs. @ 550°C.	52.0	63.8	10.0	25.0	10

sessed a magnetic permeability of 1.01.

EXAMPLE V

An alloy of the following composition:

Nickel	19.4%
Aluminium	1.8%
Manganese	4.7%
Iron	0.95%

Balance substantially all copper when cast into a sand mould and without further heat treatment possessed a magnetic permeability of 1.005.

Table 2 shows the results of corrosion tests in 3% sodium chloride solution.

Alloy No. L.20 has the following compositions:

Aluminium	1.86%
Nickel	18.2%
Manganese	4.77%
Iron	1.32%
Copper	Balance

From which it will be seen that it possesses a superior resistance to corrosion BS. 2032, BS. 2033 and HIDURAX SPECIAL.

TABLE 2

Alloy	Penetration Rate inches/month
BS. 2032	0.00022
BS. 2033	0.000222
HIDURAX SPECIAL	0.000054
ALLOY L.20	0.000019

Thus the alloys described in this specification can be produced in a variety of metallurgical forms possessing a unique combination of high strength, high ductility, low magnetic permeability and excellent corrosion resistance.

WHAT WE CLAIM IS:—

1. A copper-nickel alloy composition with constituents in the following ranges of proportions,

Nickel more than 15% and up to 32%,
Aluminium more than 0.5% but less than 5% and less than one sixth of the Nickel content,
Manganese more than 3% but less than 10% and less than half the Nickel content,
Iron 0.2% to 3%,
Balance substantially all copper.

2. A copper-nickel alloy composition according to Claim 1, of the following ranges of proportions,

Nickel between 15% and 20%,
Aluminium between 1% and 2%,
Manganese between 4% and 6%,
Iron between 1% and 2½%,
Balance substantially all copper,

and the alloys being subjected to one or more of the treatments described for the development of the desired mechanical properties.

3. A copper-nickel alloy composition with constituents in the following ranges of proportions:

Nickel more than 15% and up to 32%,
Aluminium more than 0.5% but less than 5% and less than one sixth of the Nickel content,
Manganese more than 3% but less than 10% and less than half the Nickel content,
Iron between 0.2% and 3% and
Niobium and/or Silicon between 0.2% and 3%,
Balance substantially all copper.

4. A copper-nickel alloy composition according to any of the preceding claims when hot worked in the temperature range 1000°C.-1050°C.

5. A copper-nickel alloy composition according to any one of the preceding claims when subjected to hot working and solution treatment in the temperature range 750°C.-1050°C.

6. A copper-nickel alloy composition according to any one of the preceding claims when subjected to precipitation hardening in the temperature range 350°C.-650°C.

7. A copper-nickel alloy according to any one of the preceding claims 1 to 5, which after solution treatment in the temperature range 750°C.-1050°C. is subjected to cold work, with or without subsequent precipitation hardening.

8. A copper-nickel alloy composition according to any of claims 1, 2 or 3 in the cast condition.

9. Forged articles composed of the alloy composition according to any one of claims 1 to 7 substantially as described.

10. The method of producing forged or cast articles of copper-nickel alloys according to any of Claims 1 to 3 when carried out substantially as described.

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